Detecting Ecosystem Performance Anomalies in the Upper Colorado River Basin: Implication for Land Management

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Introduction

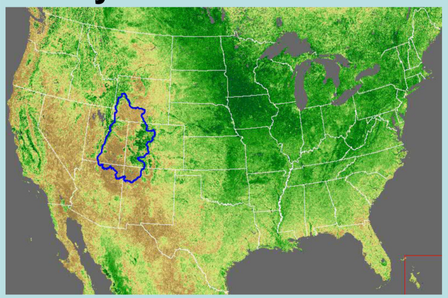
Ecosystem performance (EP) provides important information to decision makers for land management. Recently, satellite remote sensing has become an essential tool for measuring and monitoring large-area EP due to its large coverage and high spatial and temporal resolution (Wylie et al., 2008). The growing season integrated Normalized Difference Vegetation Index (NDVI) derived from satellite observation is used as a proxy for EP (Tieszen et al., 1997). Ecosystem performance anomaly (EPA) is defined as the difference between the real EP and the weather-based expected EP (EEP). Natural disasters (e.g., wildfires, floods) and anthropogenic effects (e.g., heavy grazing) usually induce significant EPA.

For moisture limited rangelands, the interannual variation in vegetation productivity is significantly related to the local weather conditions. Our approach is to separate weather and non-weather related variations in growing season NDVI (e.g., annual ecosystem performance) and make historical trend maps in both weather and non-weather related variations. In this study, we identify and quantify areas with long-term persistent EPA within the Upper Colorado River Basin based on satellite observations, climate data, and ecosystem models. The resulting EPA maps can be used by the Bureau of Land Management (BLM) for making optimal land management decisions.

Objectives

- To calculate the real ecosystem performance (EP) and the weather-based expected EP within the Upper Colorado River Basin based on satellite observations, climate data, and ecosystem models.
- To identify and quantify areas with long-term persistent ecosystem performance anomaly (EPA) within the Upper Colorado River Basin.
- To evaluate and validate the long-term persistent EPA map using ground observations (e.g., percentage of bare soil obtained from multiple research projects).

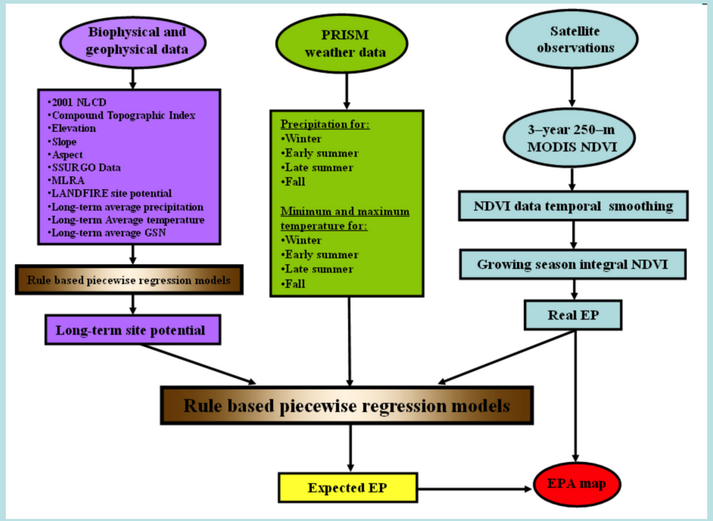
Study area



•Our study area (blue) was focused on the Upper Colorado River Basin.

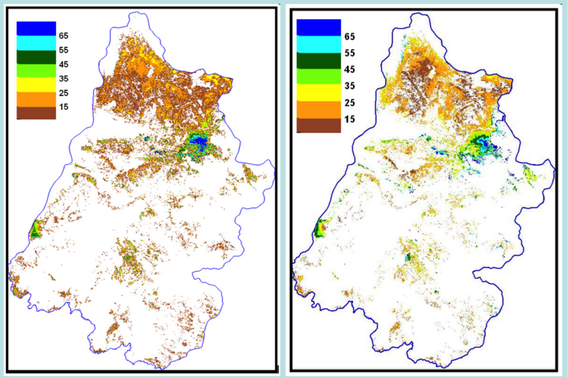
•Four vegetation cover types (grassland, big sage, pinion juniper, and salt scrub) were selected from the study area for building EP models. Only big sage results are shown here.

Methodology



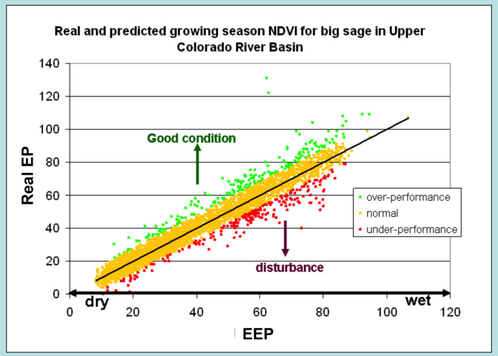
•Data inputs for calculating EP included 2005–2008 weekly 250-m eMODIS (expedited Moderate Resolution Imaging Spectroradiometer) NDVI, USGS compound topographic index and digital elevation model, USGS major land resource area and land fire environment site potential, SSURGO (Soil Survey Geographic) total site production, and PRISM (Parameter-elevation Regressions on Independent Slopes Model) monthly precipitation and temperature.

•The final Upper Colorado River Basin EPA maps were categorized as normal performance, underperformance, and overperformance (observed performance relative to weather-based predictions) at the 90% level of confidence.



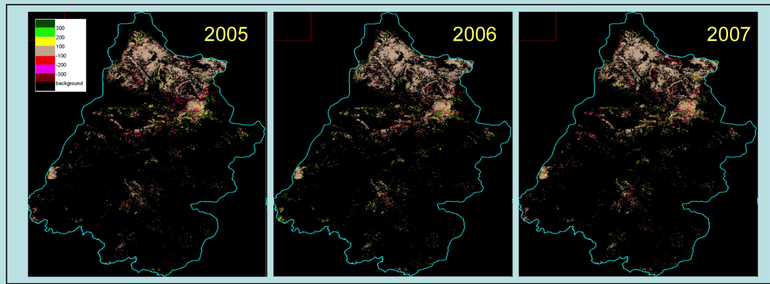
•Big sagebrush site potential (left) and expected ecosystem performance (EEP) map for 2006 (right) in the Upper Colorado River Basin.

•The final coefficient of determination (r^2) between the real EP and the predicted EP for big sagebrush is 0.94. See figure to the right.



•Comparison between EEP and the real EP for 2005–2007. Pixels were selected randomly from big sage areas.

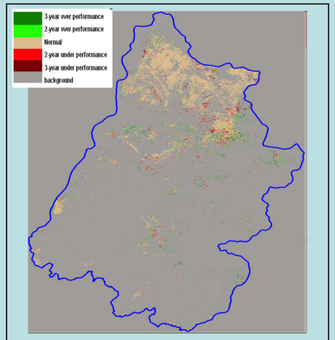
•Green points represent overperformance and are greater than 90% confidence limit above the regression line. Red points represent underperformance and are less than 90% confidence limit below the regression line.



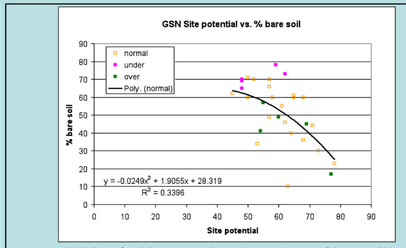
•Ecosystem performance anomaly maps for big sage areas for Upper Colorado River Basin.

•Yellow-green areas represent overperformance and are greater than the 90% confidence limit above the regression line.

•Red-pink areas represent underperformance and are greater than the 90% confidence limit below the regression line.



3-year (2005–2007) big sage persistent EPA map



•EPA validation for big sage using "percentage of bare soil" ground observations from multiple research projects. Thus, anomalies are related to range conditions.

•Regions identified as persistently underperforming (pink) tended to have a lower range condition, and regions identified as overperforming (green) tended to have a higher range condition.

Conclusions and future plans

•Long-term persistent ecosystem performance anomaly (EPA) maps within the Upper Colorado River Basin were generated based on satellite observations, climate data, and ecosystem models.

•The EPA maps agree with ground-based observations and will provide reliable information for land management decisions at the BLM by providing range conditions and weather effect histories separately.

•Continue generating 2001–2005 and 2008 EPA maps and identify long-term persistent EPA within the Upper Colorado River Basin in the future.

References

•Tieszen, L.L., et al., 1997. NDVI, C3 and C4 production, and distributions in Great Plains grassland land cover classes. Ecological Applications, 7, 59–78.

•Wylie, B.K., et al., 2008. Integrating modeling and remote sensing to identify ecosystem performance anomalies in the boreal forest, Yukon River Basin, Alaska. Int. J. Digital Earth 1(2) 172–189.

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